Post-doc internship 2022 in Lyon, France

Estimating out-of-field dose distribution based on Monte Carlo training dataset

https://www.creatis.insa-lyon.fr/site7/en/node/47203

This work is a collaboration between CREATIS lab, Léon Bérard cancer center (CLB, Lyon, France) and Institut Gustave Roussy (GRCC, Villejuif, France). It is funded by the RHU LySAIRI.

Medical and whole project context.

The Lymphocyte-Sparing Artificial Intelligence (AI)-guided Radio-Immunotherapy (LySAIRI) RHU project aims to deliver novel solutions towards the first effective implementation of immuno-radiotherapy. This internship is associated with WorkPackage #2 that aims to introduce novel dose constraints for immunological organs at risk by developing tools to quantify doses far from the irradiation field. The project brings together two internationally leading cancer care centres (GRCC, CLB), two innovative SMEs (Therapanacea, TRIBVN), and leading academic centres (UPS, INSERM, CNRS, ESSEC). Proof-of-concept will be made in patients with head and neck squamous cell carcinoma (HNSCC), due to high incidence (#5th frequency), low survival rates and recognised expertise of the clinical centres of the consortium in this field. The ultimate vision is to deliver novel clinically-validated tools with scalable application in multiple cancer types.

Scientific context of the internship.

The treatment planning software used in clinical routine underestimate doses far from the target volumes and does not allow an evaluation of the doses outside the field of view of the planning CT, which, if they are low (of the order of a few mGy to a few Gy compared to tens of Gy in the treatment field), have been shown to play a definite role in the prediction of secondary cancers caused by RT or on lymphopenia [1], [2]. For example, a recent study showed a negative correlation between integral body dose and severity of radiation-induced lymphopenia, suggesting the deleterious effect of large volumes of low doses [3].

We propose here to develop a framework able to generate a Monte-Carlo simulated training dataset composed of accurately estimated out-of-field dose distributions. This dataset will be used to train a fast DL model. This generated training dataset will be composed of pairs of corresponding dose maps, the first one being computed with standard TPS method (usually by convolution–superposition related method) and the second one with Monte Carlo (GATE [4]). Dose plans and dose distributions already available from the database of a radiation therapy department could be used to start the process. Advanced phase-space modelling with GAN [5] may be employed to adapt Monte Carlo models to each specific Linac. Generating such training dataset will require a large computational power, but will have to be performed only once and could be parallelised on clusters. We have access to several clusters (CNRS IN2P3, CNRS Jean-Zay, CREATIS lab cluster) and are experienced in this domain.

At the end of this task, a fast algorithm to compute out-of-field dose will be developed, this algorithm being trained on generated data adapted to each radiation therapy center.

First tasks of the post-doc internship.
1. Perform bibliographic review on out-of-field dose estimation methods
2. Develop Monte Carlo model for Elekta VERSA Linac able to correctly reproduce out-of-field dose distribution
3. Create a large database of dose distribution (with enough variability)
4. Investigate acceleration methods to decrease computation time

Environment. The recruited person will work in a multidisciplinary team composed of medical physicists, researchers and computer scientists of CREATIS laboratory and Leon-Bérard Cancer Center (Lyon).

Expected skills and other information

- Expected skills: medical physics, Monte Carlo, computer sciences, AI
- Technical skills: Python (required), Gate
- English and French
- Expected start: September 2022
- Duration: 3 years
- Salary: ~2100€/month (net)
- Location: Lyon, Léon Bérard Cancer Center, France
- Send CV to: david.sarrut@creatis.insa-lyon.fr and MarieClaude.BISTON@lyon.unicancer.fr

[1] U. Schneider *et al.*, "Accuracy of out-of-field dose calculation of tomotherapy and cyberknife treatment planning systems: a dosimetric study," *Z. Med. Phys.*, vol. 24, no. 3, pp. 211–215, Sep. 2014, doi: 10.1016/j.zemedi.2013.10.008.

[2] A. R. Wolfe *et al.*, "Increasing neutrophil-to-lymphocyte ratio following radiation is a poor prognostic factor and directly correlates with splenic radiation dose in pancreatic cancer," *Radiother. Oncol. J. Eur. Soc. Ther. Radiol. Oncol.*, vol. 158, pp. 207–214, May 2021, doi: 10.1016/j.radonc.2021.02.035.

[3] N. Joseph *et al.*, "Post-treatment lymphocytopaenia, integral body dose and overall survival in lung cancer patients treated with radical radiotherapy," *Radiother. Oncol. J. Eur. Soc. Ther. Radiol. Oncol.*, vol. 135, pp. 115–119, Jun. 2019, doi: 10.1016/j.radonc.2019.03.008.

[4] D. Sarrut *et al.*, "A review of the use and potential of the GATE Monte Carlo simulation code for radiation therapy and dosimetry applications," *Med. Phys.*, vol. 41, no. 6Part1, p. 064301, Jun. 2014, doi: 10.1118/1.4871617.

[5] D. Sarrut, N. Krah, and J. M. Létang, "Generative adversarial networks (GAN) for compact beam source modelling in Monte Carlo simulations," *Phys. Med. Biol.*, vol. 64, no. 21, p. 215004, Oct. 2019, doi: 10/gf82xv.